

for a smokeless powder suitable for field artillery and small arms.

The properties of ammonium nitrate, of which the products of decomposition by heat are, in addition to water-vapour, entirely gaseous, have rendered it a tempting material to work upon in the hands of those who have striven to produce a smokeless powder, but its deliquescent character has been the chief obstacle to its application as a component of an explosive agent susceptible of substitution for black powder for service purposes.

A German chemical engineer, F. Gäus, conceived that, by incorporating charcoal and saltpetre with a particular proportion of ammonium nitrate, he had produced an explosive material which did not partake of the hygroscopic character common to other ammonium-nitrate mixtures, and that, by its explosion, the potassium in the saltpetre formed a volatile combination with nitrogen and hydrogen, a *potassium amide*, so that, although containing nearly half its weight of potassium salt, it would furnish only volatile products. The views of Mr. Gäus regarding the changes which his so-called *amide powder* undergoes upon explosion were not borne out by existing chemical knowledge, while the powder compounded in accordance with his views proved to be by no means smokeless, and was certainly not non-hygroscopic. Mr. Heidemann has, however, been successful, by modifications of Gäus's prescription and by application of his own special experience in powder-manufacture, in producing an ammonium-nitrate powder possessed of remarkable ballistic properties, furnishing comparatively little smoke, which speedily disperses, and exhibiting the hygroscopic characteristics of ammonium-nitrate preparations in a decidedly less degree than any other hitherto prepared. The powder, while yielding a very much larger volume of gas and water-vapour than black or brown powder, is considerably slower than the latter; the charge required to produce equal ballistic results is less, while the chamber-pressure developed is lower, and the pressures along the chase of the gun are higher, than in the case of brown powder.

The ammonium-nitrate powder contains, in its normal, dried condition, more water than even brown powder; it does not exhibit any great tendency to absorb moisture from an ordinarily dry or even a somewhat moist atmosphere, but if the amount of atmospheric moisture approaches saturation, it will rapidly absorb water, and when once the process begins it continues rapidly, the powder-masses becoming speedily quite pasty. The charges for quick-firing guns are enclosed in metal cases, in which they are securely sealed up; the powder is therefore prevented from absorbing moisture from the external air, but it has been found that if the cartridges are kept for long periods in ships' magazines, in which, from their position relatively to the ships' boilers, the temperature is more or less elevated, sometimes for considerable periods, the expulsion of water from some portions of the powder-masses composing the hermetically sealed charge, and its consequent irregular distribution, may give rise to want of uniformity in the action of the powder, and to the occasional development of high pressures. Although, therefore, this ammonium-nitrate powder may be regarded as the first successful advance towards the production of a comparatively smokeless artillery powder, it is not uniformly well adapted to the requirements which it should fulfil in naval service.

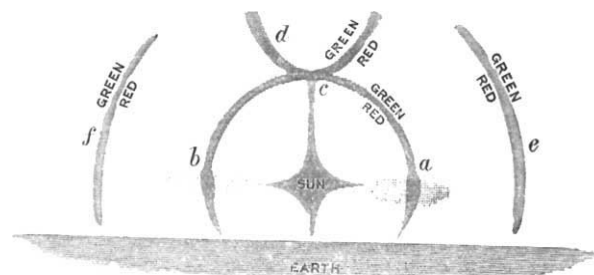
Attention was first seriously directed to the subject of smokeless powder by the reports received about four years ago of remarkable results stated to have been obtained in France with such a powder for use with the magazine rifle (the Lebel) which was being adapted to military service. These reports were speedily followed by others, descriptive of marvellous velocities obtained with small charges of this powder, or some modifications of it, from guns of very great length. As in the case of melinite, the fabulously destructive effects of which were much vaunted at about the same time, the secret of the precise nature of the smokeless powder was so well preserved by the French authorities, that surmises could only be made on the subject even by those most conversant with these matters. It is now well known, however, that more than one smokeless explosive has succeeded the original powder, the perfection of which was reported to be beyond dispute, and that the material now adopted for use in the Lebel rifle bears, at any rate, great similarity to preparations which have been made the subject of patents in this country, and which are still experimental powders in other countries.

(To be continued.)

SOLAR HALOS AND PARHELIA.

THE recent appearance of solar and lunar halos, parhelia, and paraselene, has called forth a considerable amount of correspondence from all parts of the country, and the accompanying figure may be taken as a composite representation of the solar phenomenon observed. A glance at the times at which the halos were observed on the 29th ult., makes it apparent that they occurred earliest in places of highest latitudes. At Driffeld, in lat. 54° , the halo, with its attendant parhelia, was observed at 1.34 p.m., and the whole phenomenon disappeared at 2.8 p.m.; at Burton-on-Trent, lat. $52^{\circ} 48'$, the halos and parhelia were first observed at 2 p.m., and lasted more or less distinctly until 3 p.m.; whilst about a degree south of this, at Oxford, Colnbrook, and Walton-on-Thames, the phenomena occurred from about 3.30 to 4.30. The uniform difference in the times when the halos were observed at the places of different latitudes necessarily follows from the fact that they are formed by the action upon solar rays of prismatic crystals of ice suspended in the air by the ascending currents which especially occur in the spring and autumn. Those prisms that are in such positions that the rays from the sun in transmission through them suffer minimum deviation are the cause of the formation of halos, and since the angular distance of the sun equal to minimum deviation is about 22° , this must be the radius of the halo, and the external circle, being produced by two such refractions in succession, has a radius of about 46° .

The halos recently observed do not differ in the main from those frequently seen in higher latitudes, and consisting of (1) a first circle or halo concentric with the sun, red within, violet without, and at an angular distance of 22° or 23° ; (2) a second circle or halo, similar to the preceding, but at an angular dis-



a was seen at 3.35 p.m.; *b* at 3.45 p.m.; *c* and *d* at 3.50 p.m.; *e* at 4.0 p.m.; *f* at 4.10 p.m.

tance of 46° ; (3) a portion of the *parhelic* circle appearing horizontal and diametral, and at the points of junction of this circle with the two halos, there is increased luminosity, which have been taken for images of the sun; (4) horizontal arcs, tangents to the circular halos, and a vertical line making a cross with the horizontal portion of the parhelic circle.

Mr. John Lovell thus describes the phenomena observed at Driffeld:—"A splendid solar halo, with its attendant parhelia, was observed this afternoon at 1.34 local time. The halo (diameter 45°) was almost perfect, the lower part only being slightly obliterated by the thick atmosphere near the horizon. Attached to the upper side, an inverted portion of a similar halo appeared, brilliantly illumined on the concave side, the lower part giving out a dull red light. Again, $22\frac{1}{2}^{\circ}$ above this, and also inverted, about 60° of arc beautifully coloured with rainbow colours was clearly visible, the red side lowest. This arc, if it had been produced, would have circled the zenith. The mock lights on each side of the halo were drawn out into long cones of intensely bright light, while the inner sky of the halo was of a very dark shade. The most noteworthy feature of the display was a brilliant patch of pure white light in the north-western sky, at a distance of 90° from the western mock sun, and undoubtedly emanating from it, and which remained visible for nearly ten minutes. The whole phenomena disappeared at 2.8 p.m., the sky then being covered with streaky cirro-stratus haze from the north-north-west."

The patch of white light referred to by Mr. Lovell was doubtless produced by the junction of the parhelic circle with one of the halos concentric with the sun. It is perhaps hardly necessary to note the relation that exists between halos and cirro-

stratus clouds, and that the space included within the halo is frequently of a more intense grey, or of a deeper blue than the rest of the sky.

The son of Sir W. Herschel observed the phenomena at Oxford, and noted:—"The sun was near the horizon. On either side of it, at a distance of five or six diameters of the sun, was a mock sun, not very bright, of the colours of the rainbow, the one on the right being the brighter. There was a scarcely perceptible rainbow, of which red was the only colour visible, joining the two mock suns. This rainbow was brightest directly over the sun. As far off again as the first was a second rainbow, hazy, but fairly bright, which was equally visible from earth to earth. Vertically above the sun, a third, a very bright rainbow, touched the second, being inverted, and having its centre straight overhead. It did not look quite as large as the second. The weather was clear, but the clouds on and above the horizon were of a uniform grey colour, fading off gradually to a nearly clear sky overhead. There seemed always to be a much lighter shade of grey in the clouds where the sun and the two mock suns were."

The coloured parhelia observed indicates the refraction and dispersion of solar light by vertical prisms, whilst the phenomena of inverted arches are produced by the light which passes through horizontal crystals, at different azimuths.

Mr. Frank E. Lott, at Burton-on-Trent, observed a third parhelia on the part of the first halo vertically above the sun, whilst Mr. H. G. Williams, of Caterham, observing the phenomena about 4 p.m., noted that the sun appeared about 10° above the horizon. So far, the observations of two or three parhelia with two halos and two inverted arches agree with many former descriptions. In the diagram appended, however, and in the majority of sketches received, the inverted arch is not given as the arc of a circle, but hyperbolic.

Mr. A. J. Butler, observing at Walton-on-Thames, remarks: "The hyperbolic band above the sun was carefully noted;" and Mr. C. A. Carus-Wilson, in the following observation made at Staines, supports this view:—

"The sun was just setting behind a bank of hazy mist, appearing as a crimson disk enveloped in blue grey cloud; I first noticed a distinct bow, of light grey tint, and coloured for a short distance at its left extremity with the ordinary rainbow tints—red inside. There then appeared a part of a second bow outside the other, coloured throughout the whole length visible—red inside. From the sun vertically upwards to the first bow, there was a band of white light, quite distinct from the light grey tint of the lower bow, and above the lower bow this band continued as a hyperbolic brush of white light: this brush was much brighter and better defined than the vertical band. A hasty measurement, with a pocket sextant, of the angular radii of the two bows, gave 46° and 23° for the outside and inside bows respectively."

Mr. H. W. Pyddoke also remarks:—"The most noticeable thing of all was the shape of the upper bow, which was like a hyperbole except at its ends where it bent round again very slightly;" and other correspondents concur in this description of the shape of the first inverted arch.

From the descriptions and figures given it is evident that the two parhelia on the parhelic circle are the respective centres of halos similar to the first halo concentric with the real sun; the intersection of these two circles with that surrounding the sun gives the appearance of a hyperbolic curve at the top of it. An exactly similar appearance was drawn by Pastorff as occurring on December 29, 1789, and is found in his "*Beobachtungen der Sonnenflecke*"; and *L'Astronomie* for August 1889 contains a drawing and description of a very similar appearance.

Lunar halos followed the solar halos on the 29th ult., and on the following day Mr. G. B. Buckton, F.R.S., observed three fine parhelia and a halo at Haslemere, and describes them as follows:—

"The sun shone brightly, but through a moderate haze. On the right and on the left, at equal altitudes with the sun, an oblong bright patch of light appeared. That on the left was the brightest, and formed a blurred image of the sun with all the prismatic colours of the rainbow, but the colours were reversed in order. The upper and lower parts of these mock suns were drawn out, and formed portions of a large circle of about (by eye estimate) 20° radius. These images were connected with the haze, but a lower stratum of finely striated cloud came between the eye and these patches. Immediately above the true sun a third patch of light occurred, through which a portion of an in-

verted circle was seen, the greater part of which was lost in the blue of the sky above. The right-hand mock sun was fainter than the other, on account of the grey haze being more dense."

Mr. Buckton's observation is a demonstration of the principle laid down—namely, that parhelia always appear at the same elevation as the true sun, and are united to each other by a white horizontal circle, whose pole is the zenith. This circle changes in elevation with the true sun; and the apparent semi-diameter is always equal to the distance of the luminary from the zenith.

Mr. Nagel, of Trinity College, Oxford, notes that:—"The solar halos on the afternoon of January 29 were very clearly seen in Oxford; the tangential arc to the outer halo was extremely brilliant, and the two mock suns at the extremities of the horizontal diameter of the inner halo were well marked. During part of the time the halos lasted, a whitish incomplete circle was seen about 80° from the sun, and consequently beyond the zenith. This circle seemed to correspond to that first described by Helvelius in 1661."

It is evident from the descriptions given that the parhelia are not, as is sometimes supposed, images of the real sun at all, but only the junctions of two of the circles formed. The upper and the lower parts of these mock suns were drawn out and connected with the first halo, whilst their sides were observed to be drawn out and to merge into the parhelic circle.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE forty-third annual general meeting of the Institution of Mechanical Engineers took place on January 29, 30, and 31, in the theatre of the Institution of Civil Engineers.

The papers down for reading and discussion were as follows: on the compounding of locomotives burning petroleum refuse in Russia, by Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, South-East Russia; on the burning of colonial coal in the locomotives on the Cape Government railways, by Mr. Michael Stephens, Locomotive Superintendent; and on the mechanical appliances employed in the manufacture and storage of oxygen, by Mr. Kenneth S. Murray, of London. The latter paper was communicated through Mr. Henry Chapman.

Mr. Urquhart's paper is one of a series of excellent and thoroughly useful descriptions of work done by that gentleman on his railway, and had been for some time promised to the Institution. In order to satisfy himself as to the utility and saving of fuel in compound locomotives, he obtained the sanction of the Government for altering one locomotive by way of experiment. The altered engine was put to work, and the driver was allowed over a month's running to get fully acquainted with the handling in regular service. Comparative trials were then made of the compound against a non-compound locomotive with the same weight of train, on the same days, so as to expose them both to the same circumstances in regard to weather. It was clearly proved that the compound burnt 22 per cent. less of the petroleum refuse used as fuel than the non-compound engine, and the author's experience has left no doubt in his own mind that compound locomotives are the engines of the future in all countries. Mr. Urquhart's results are thoroughly borne out by those obtained in this country by Messrs. Worsdell and Webb. Some engineers suppose that this great economy in fuel is due to the higher working steam pressure, and therefore greater expansion in the compound engines as compared with the non-compound engines.

The paper by Mr. Michael Stephens is a description of the South African coal-fields, their discovery, and general working within the last sixteen years. It appears from the paper that the local coal cannot be burned to advantage without a special arrangement of fire-bars—as may be well imagined, since it contains nearly 30 per cent. of incombustible matter.

Mr. Kenneth S. Murray gives an interesting account of the commercial preparation of oxygen from the atmosphere by means of the alternate heating and cooling of the monoxide of barium. About thirty years ago the eminent French chemist Boussingault made the discovery that, at a temperature of about 1000° F., the monoxide of barium would absorb oxygen readily from the atmosphere, with the resulting formation of the dioxide;